HEWLETT hp PACKARD

FREQUENCY SYNTHESIZER

model 5100A and 5110A

TECHNICAL DATA 1/15/65

DC TO 50 MC

DIGITAL FREQUENCY SELECTION

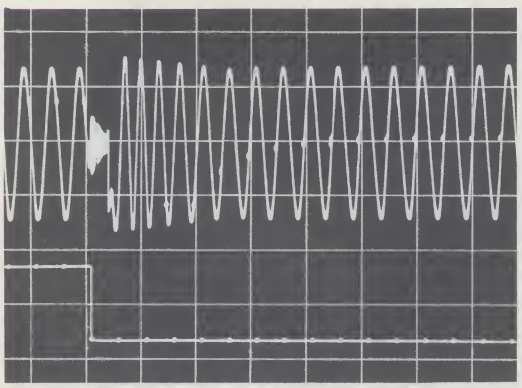
0.01 CPS FREQUENCY INCREMENTS

1 MILLISEC SWITCHING

SPURIOUS 90 DB DOWN

HIGH STABILITY

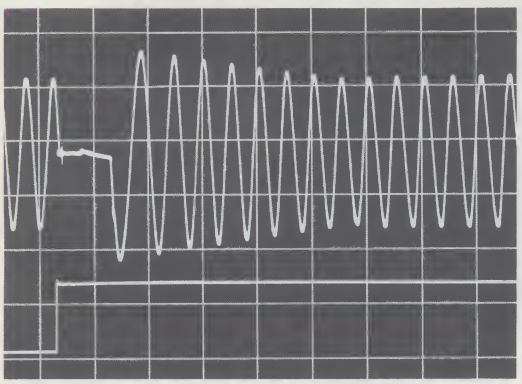
SOLID STATE RELIABILITY



29.9 to 30.1 Mc (30 Mc subtracted), 20 μsec/cm
(100 Kc markers)

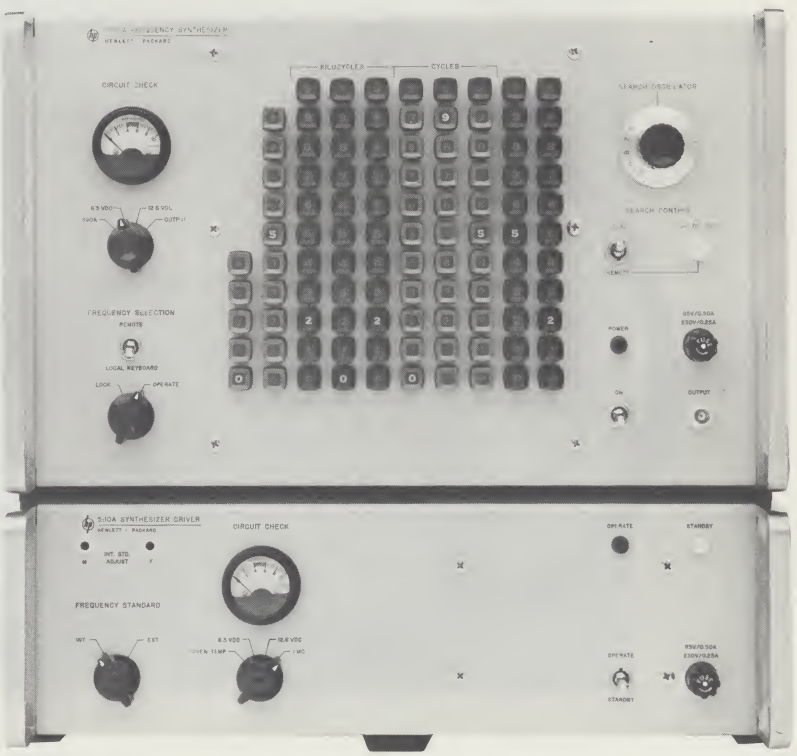
HIGH SPEED SWITCHING

29.9 to 30.1 Mc (30 Mc subtracted), 20 μsec/cm



05100-A-21

The Hewlett-Packard Model 5100A/5110A Frequency Synthesizer provides any output frequency from 0.01 cps to 50 Mc, selectable in steps as small as 0.01 cps. The output frequency is derived from a precision single frequency source through direct synthesis, a technique which translates the stability and spectral purity of the source to the selected output. A precision quartz oscillator of extreme stability is provided, or an external 1 Mc or 5 Mc standard may be used.



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Particular care has been exercised in the design of the Model 5100A/5110A to insure that a very clean output signal is provided over the entire frequency range. A high order of spectral purity is essential for accurate doppler measurements, microwave spectroscopy, narrow band telemetry or communications, and similar applications. The design and construction of the Hewlett-Packard Frequency Synthesizer make it possible to obtain output signals with a spurious content at least 90 db below the selected output.

The 5110A Synthesizer Driver generates 22 spectrally pure signals from the standard signal. These 22 frequencies are then fed to the 5100A Frequency Synthesizer by means of rear panel BNC connectors (Figure 1), and are continuously available. The variable output signal is synthesized from these fixed frequencies by a series of arithmetic operations.

Since no phase-locked loops are involved, switching from one output frequency to another can be accomplished very rapidly, either from the front panel push-buttons or remotely. Less than one millisecond is required to change output frequency. For applications requiring rapid frequency selection, Model 5100A/5110A is arranged for remote control through rear connectors.

OPERATIONAL FEATURES

Remote Control—Less than one millisecond switching time offers control flexibility never before possible.

Any frequency or search oscillator position that can be selected by front panel push-buttons may also be remotely selected. Three fifty-pin connectors located on the 5100A rear panel (Figure 1) provide pins corresponding to each front panel push-button position, a ground connection, and a — 12.6 volt line for use in remote programming. The — 12.6 volts is available in two arrangements—continuous and switched (present when REMOTE mode is selected at front panel). This lends additional versatility since it enables the use of a combination of remote and local programming.

An actual contact closure such as a relay is not required for remote control of the Synthesizer. The required — 12.6 volts DC may be applied to the selected pin electronically.

Figure 2 is representative of one of the many applications made possible by the Synthesizer's remote programming capability. This plot of the response of a single sideband crystal filter was obtained by programming the Synthesizer to generate frequencies in a variety of incremental steps. Less than one minute was required for the complete plot.

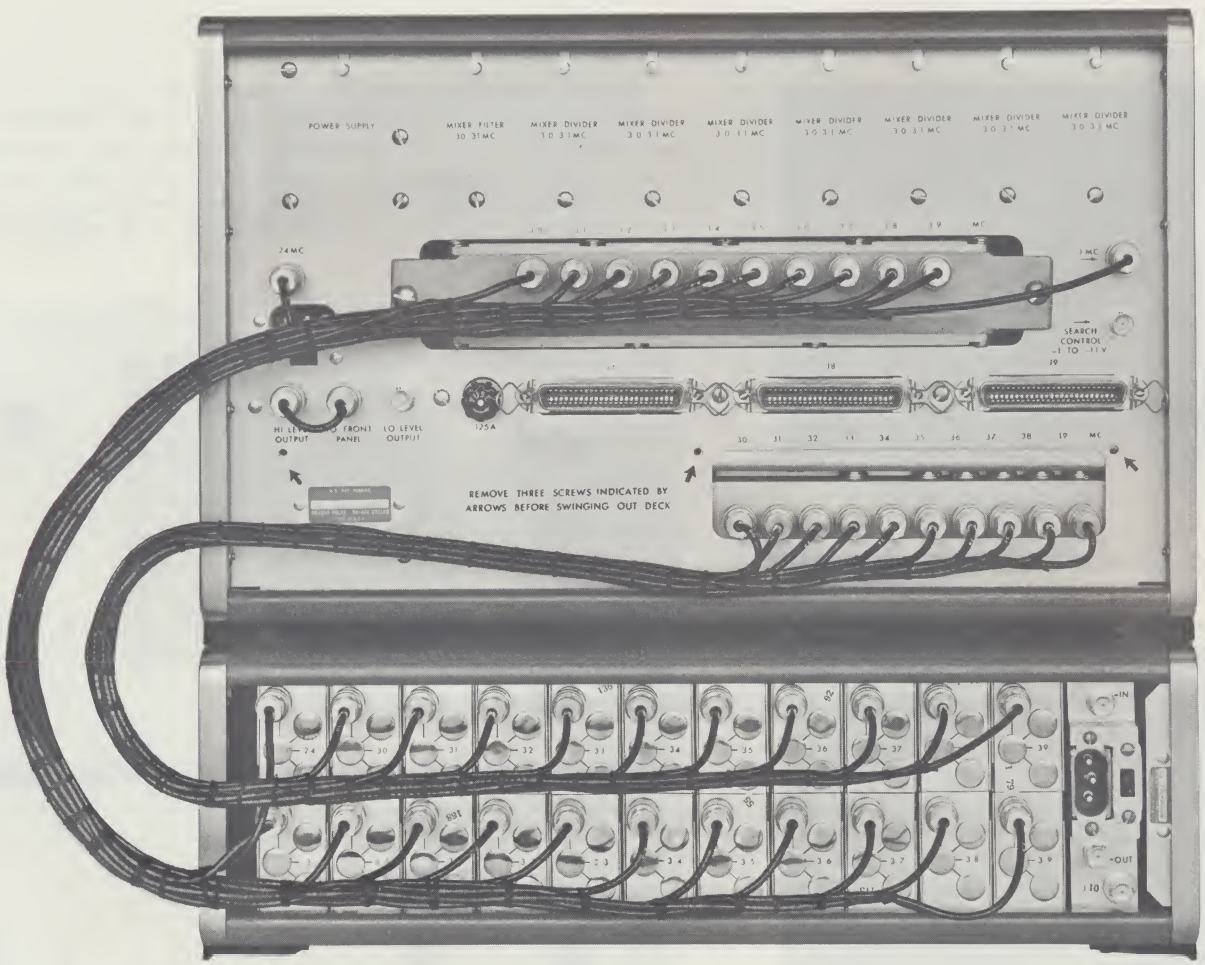


Figure 1

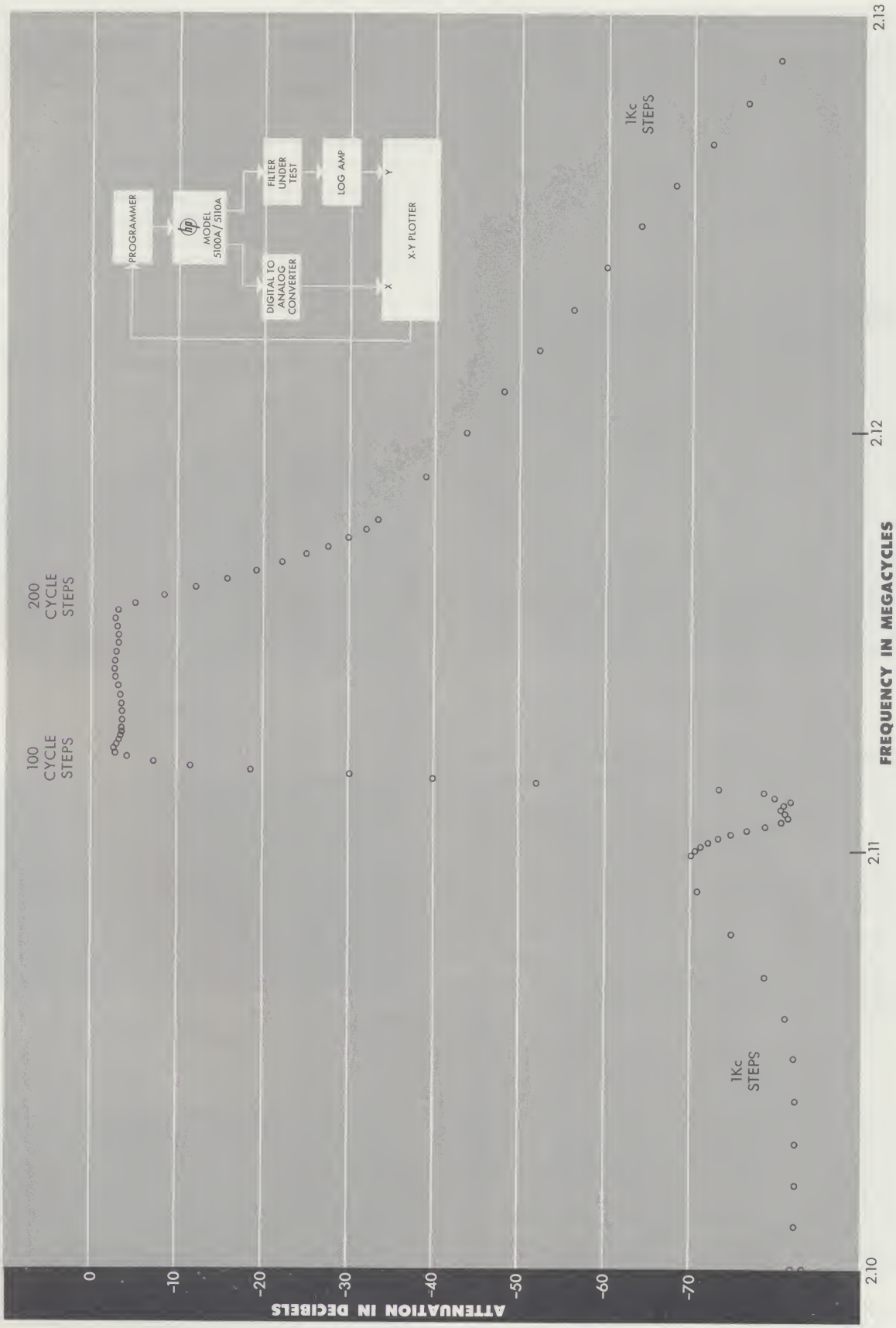

PROGRAMMER
MODEL 5100A/5110A
DIGITAL TO ANALOG CONVERTER
FILTER UNDER TEST
LOG AMP
X-Y PLOTTER
X
Y
100 CYCLE STEPS
200 CYCLE STEPS
1Kc STEPS
1Kc STEPS
0
-10
-20
-30
-40
-50
-60
-70
ATTENUATION IN DECIBELS
2.10
2.11
2.12
2.13
FREQUENCY IN MEGACYCLES

Figure 2

SEARCH OSCILLATOR

Continuous tuning and sweep capability add versatility for a wide variety of applications. The search oscillator is an L-C oscillator which allows the operator to continuously "search" any significant column from 100 Kc to 0.01 cps, either manually by front panel dial or remotely by application of a suitable voltage. The typical voltage vs. frequency characteristic is shown in Figure 3. The approximate slope is 10% of the selected column's range per volt.

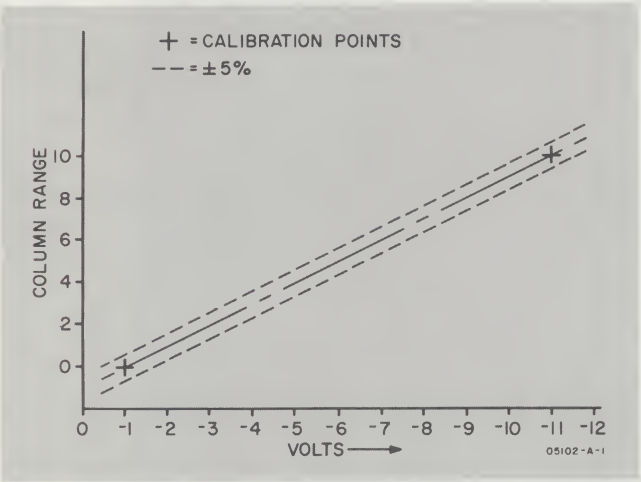


Figure 3

If the search oscillator is used, the stability of the Synthesizer output is determined by either that of the standard instrument or that of the search oscillator. The search oscillator has a root-mean-square deviation of approximately 1 cycle (one second average) if used in the most significant column that can be searched (100 Kc steps). This Δf_{rms} is reduced by a factor of 10 for each less significant column that is searched. As an example, consider that the search oscillator is used in the 10 Kc step column, at an output frequency in the 10 Mc region. The instability in the output frequency due to the search oscillator is then:

$$\frac{\Delta f_{rms}}{f_{out}} = \frac{0\ 1\ cps}{10 \times 10^6\ cps} = 1 \times 10^{-8}$$

At this output frequency, and using one second averaging, the short term stability of the Synthesizer itself is on the order of 3×10^{-11}. Consequently, the search oscillator governs in this case.

The search oscillator may be frequency modulated from an external source (sinewave) at a maximum rate of 1 Kc while retaining the voltage control calibration.

The plots displayed in Figures 4, 5, 6, and 7 are representative of the impressive versatility of the Frequency Synthesizer. The microwave spectral lines of Cs^{133} were obtained using the system shown in Figure 4.

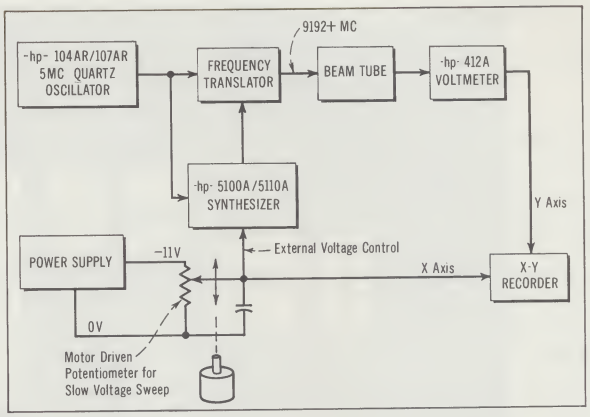


Figure 4

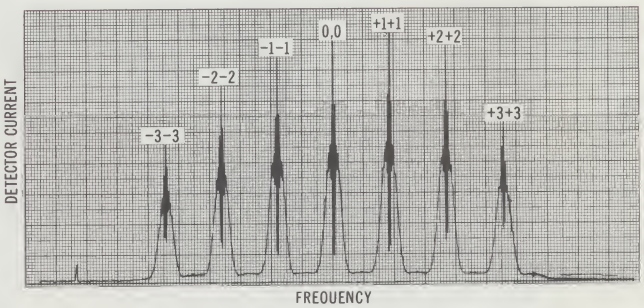


Figure 5

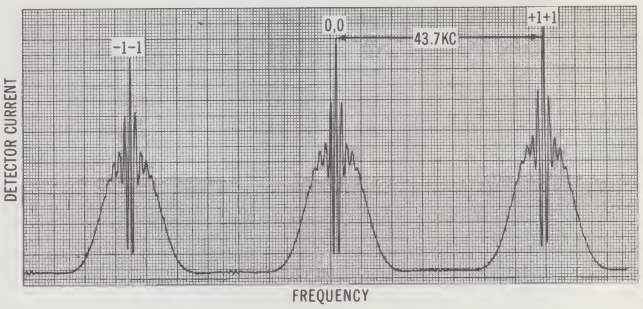


Figure 6

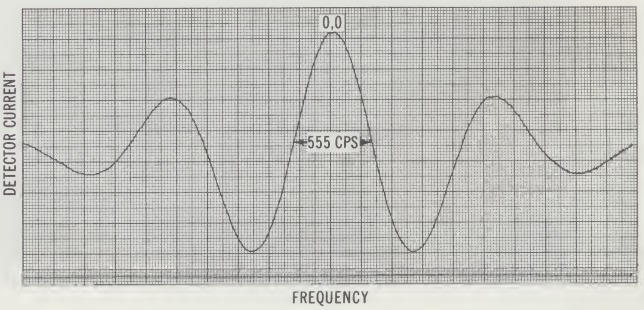


Figure 7

The frequency translator adds the Synthesizer output to a fixed harmonic of the stable 5 Mc source to provide an excitation frequency of 9192+ Mc. A desired significant column of the Synthesizer output is continuously swept by employing the external voltage control feature of the Synthesizer's search oscillator. The three plots were obtained by searching successively less significant columns. This type of system greatly simplifies the investigation of the homogeneity of the small magnetic field used in the region where Cesium hyperfine transitions occur. For further details see the Hewlett-Packard Journal, Vol. 15, No. 4, December, 1963.

SPECTRAL PURITY AND SHORT TERM STABILITY

Many applications require that a signal be multiplied into the microwave region. If the frequency multiplying device is broadband, the ratio of total sideband power to signal power increases as the square of the multiplying factor. Since the total power in a frequency modulated wave is constant, the increased sideband power must come from the carrier. The spectrum of the signal begins to "spread" since the increased sideband amplitude causes the intermodulation between sidebands to become appreciable. It is desirable, then, that the original signal have the highest possible signal to phase noise ratio. Figure 8 shows the log plot of phase noise present on the output signal of the 5100A/5110A at 49 Mc. Figure 9 is a wave analyzer's approximation to the voltage spectrum of a 1 Kc beat between two independent synthesizers individually multiplied from 2.2 Mc to 8.75 Gc. Narrow width here of < 1 cps indicates high quality of original synthesizer signal.

The specified values for RMS Fractional Frequency Deviation at various averaging times and at various output frequencies represent the standard deviation of the short term frequency instability due to random noise. For example, the value given for one second averaging at an output of 50 Mc is 6×10^{-11}. This corresponds to an RMS or standard frequency deviation of 0.0030 cps. In other words, 68.3% of all observed frequency variations for measurement times of one second will differ from the carrier by less than plus or minus that amount. 99.7% of all frequency variations will differ from the carrier by less than $\pm$ 0.0090 cps. All statistical data are based on one hundred samples.

MODULAR CONSTRUCTION

Solid-state modular construction has been used throughout the 5100A/5110A. The modular concept enables the system to meet the stringent demands regarding spurious signals since the isolation that it affords minimizes spurious coupling. It also enhances serviceability. Careful design and quality control insure that all modules are interchangeable from one instrument to another.

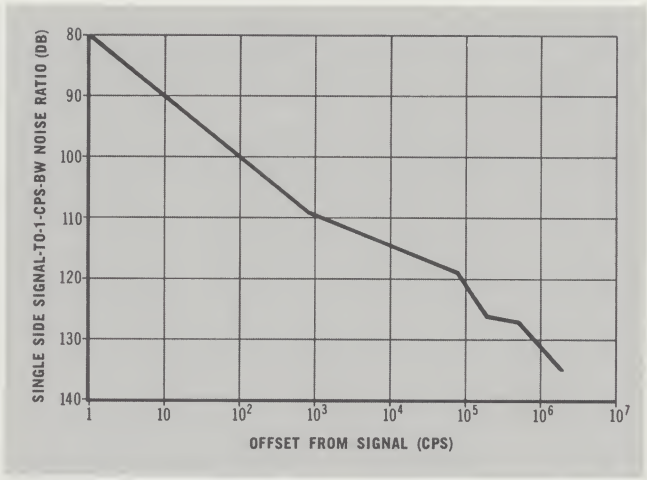


Figure 8

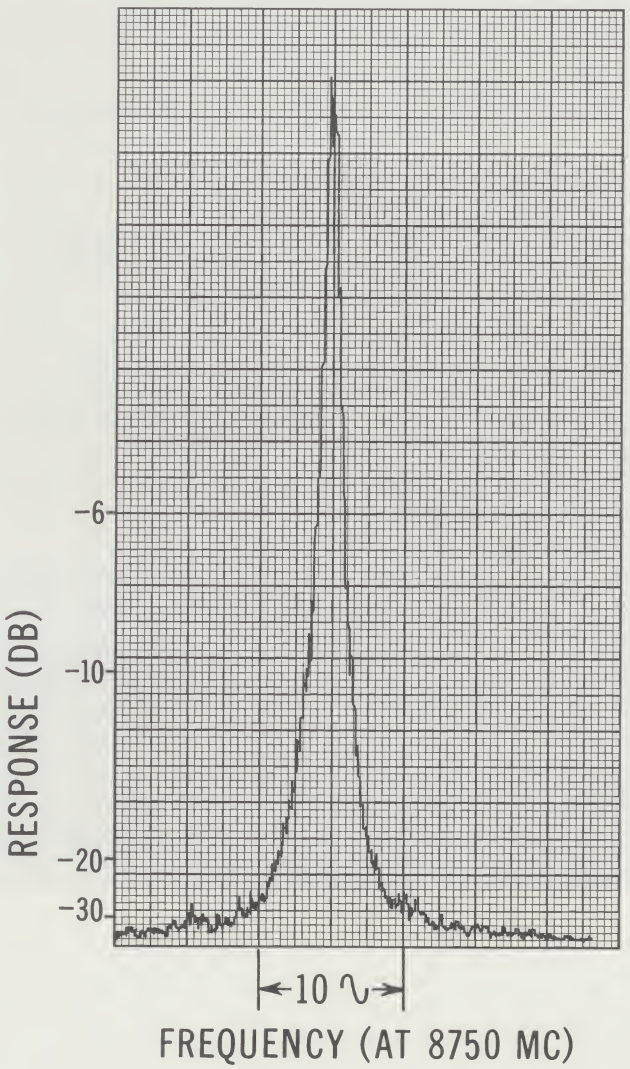


Figure 9

SPECIFICATIONS

5100A FREQUENCY SYNTHESIZER

OUTPUT FREQUENCY: DC to 50 Mc.

DIGITAL FREQUENCY SELECTION: 0.01 cps through 10 Mc per step. Selection by front panel push-button or by remote switch closure. Any change in frequency may be accomplished in less than 1 millisecond.

OUTPUT VOLTAGE: 1 volt rms ± 1 db from 100 Kc to 50 Mc. 1 volt rms + 2 db, — 4 db from 50 cps to 100 Kc, into a 50-ohm resistive load. Nominal source impedance is 50 ohms. 15 millivolts rms minimum open circuit from 100 Kc down to DC, at separate rear output connector, source impedance of 10,000 ohms with shunt capacitance approximately 70 pf.

SEARCH OSCILLATOR: A search oscillator provides continuously variable frequency selection with an incremental range of 0.1 cps through 1 Mc. Manual or external voltage (— 1 to — 11 volts) control with linearity of ± 5%.

SIGNAL-TO-PHASE NOISE RATIO: Greater than 54 db in a 30-Kc band centered on the signal (excluding a 1-cps band centered on the signal).

SIGNAL-TO-AM NOISE RATIO (Above 100 Kc): Greater than 74 db in a 30-Kc band.

RMS FRACTIONAL FREQUENCY DEVIATION (With a 30-Kc noise bandwidth):

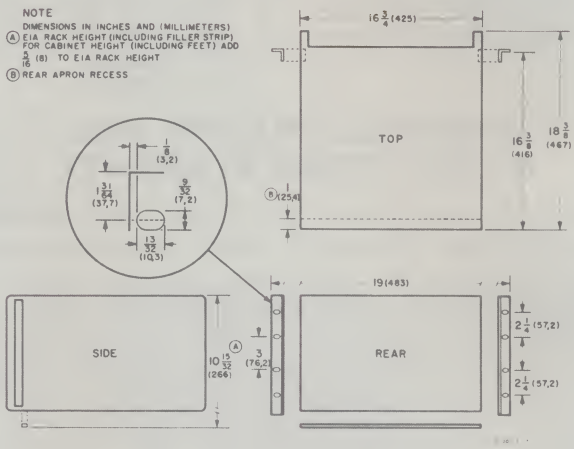
Averaging Time	Output Frequency			
	1 Mc	5 Mc	10 Mc	50 Mc
10 milliseconds	3×10^{-8}	6×10^{-9}	3×10^{-9}	6×10^{-10}
1 second	3×10^{-10}	6×10^{-11}	3×10^{-11}	1×10^{-11}

SPURIOUS SIGNALS: Non-harmonically related signals are at least 90 db below the selected frequency.

HARMONIC SIGNALS: 30 db below the selected frequency (when terminated in 50 ohms).

Note: When the 5110A Driver utilizes an external frequency standard, this will affect the stability and spectral purity of the output. Performance data stated above are based on internal frequency standard or indicate Synthesizer contribution to over-all performance with external standard.

DIMENSIONS:



WEIGHT: Net, 75 lbs. *(34 kg)*. Shipping, 127 lbs. *(58 kg)*.

PRICE: $10,250.00 (requires 5110A).

EQUIPMENT FURNISHED: 05100-6180 Decade Test cable, 05100-6066 Output cable, 05100-6212/13 cable assembly connects 5100A Synthesizer to 5110A Driver. Permits rack mounting of up to two 5100A's immediately above and/or below the 5110A Driver. A special-length cable assembly will be required for other mounting arrangements.

SPECIAL CABLE: If a special-length cable assembly is required, order spec C05-5110A. Specify configuration and length (max. separation 50 feet). Cable is supplied in five-foot sections only. Price: $40 per section.

5110A SYNTHESIZER DRIVER

OUTPUT FREQUENCIES: Provides 22 fixed frequencies for the 5100A Frequency Synthesizer: 3.0 through 3.9 Mc in 0.1 Mc steps (50 mv + 1, — 3 db) 30 through 39 Mc in 1 Mc steps, 24 Mc, and 3 Mc (100 mv ± 1.5 db), 50-ohm system.

1 Mc buffered output (1 volt ± 1.5 db into a 50-ohm resistive load) available at rear panel connector.

INTERNAL FREQUENCY STANDARD: 1 Mc Quartz Oscillator.

AGING RATE: Less than ± 3 parts in 10^9 per day.

STABILITY: As a function of ambient temperature: ± 2 x 10^{-10} per °C from 0°C to + 55°C.

As a function of line voltage: ± 5 x 10^{-11} for a ± 10% change in line voltage (rated at 115 or 230 volts rms line voltage).

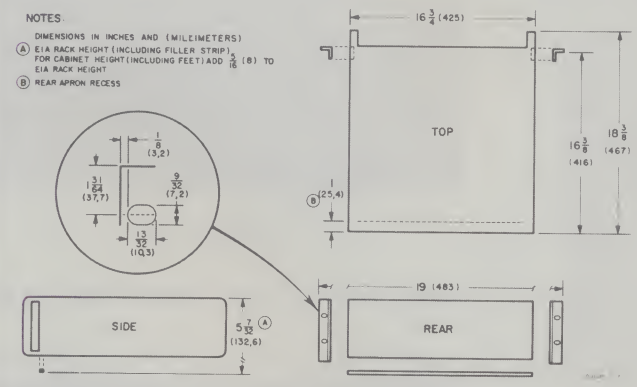
Short term (with internal crystal filter): Adequate to provide the 5100A performance noted above (1 x 10^{-11} rms for 1 second averaging on direct output for 30-Kc noise bandwidth).

PHASE LOCKING CAPABILITY: A voltage control feature allows 5 parts in 10^8 frequency control for — 5 to + 5 volts applied. Greater than 50 K ohms input impedance at DC.

EXTERNAL FREQUENCY STANDARD:

Input Requirements: 1 or 5 Mc, 0.2 v rms minimum, 5 v maximum across 500 ohms. Stability and spectral purity of 5100A Frequency Synthesizer will be partially determined by the characteristics of the external standard if used.

DIMENSIONS:



WEIGHT: Net, 54 lbs. *(25 kg)*. Shipping, 60 lbs. *(27 kg)*.

PRICE: $5,000.00.

OPTIONAL FEATURES: The 5110A Synthesizer Driver is capable of driving up to four 5100A Frequency Synthesizers.

Option 02: Outputs for driving two 5100A Synthesizers. Price $125.00.

Option 03: Outputs for driving three 5100A Synthesizers. Price $235.00.

Option 04: Outputs for driving four 5100A Synthesizers. Price $345.00.

Note:

1. If Option 02-04 is selected, the additional outputs must be terminated in 50 ohms when not connected to a 5100A Synthesizer if full specified spurious performance is required.

   Accessory Available: 50 ohm BNC termination Stock No. 10510A. (22 required for each set of outputs not connected; e.g., maximum requirement would be 66 when Option 04 is selected but only one 5100A is being driven.) Price: $5.00 each.

2. A special interconnecting cable may be required for driving additional 5100A Synthesizers (see Special Cable, 5100A above).

3. Small phase jumps (less than 1 radian) will be experienced on one 5100A output when another 5100A, connected to the same 5110A, is switched from one frequency to another.

GENERAL

OPERATING TEMP. RANGE: 0 to + 55°C.

INTERFERENCE: Complies with MIL-I-26600, Class 1 and 3, MIL-1-6181D.*

SUSCEPTIBILITY: Complies with MIL-I-26600, Class 1 and 3, MIL-I-6181D.

POWER: 115 or 230 volts ± 10%, 50 to 400 cycles, 35 watts each unit (independent supplies).

** Interference compliance requires that the 5100A and 5110A are connected by a low inductance path such as adjacent rack mounting.*

Prices f.o.b. factory
Data subject to change without notice

HEWLETT hp PACKARD

FREQUENCY SYNTHESIZER

model 5102A

TECHNICAL DATA 1 AUG 65

DUAL RANGE

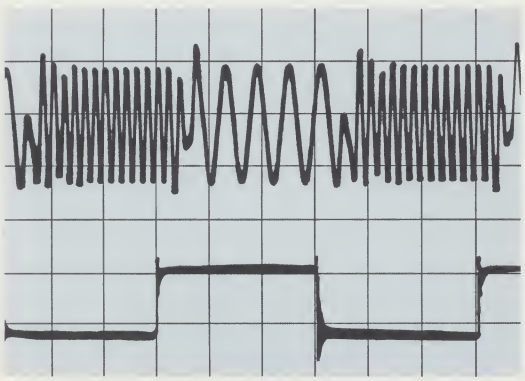
DC to 100 Kc, Spurious 90 DB Down
DC to 1 Mc, Spurious 70 DB Down

DIGITAL FREQUENCY SELECTION

SEARCH OSCILLATOR

20 MICROSEC SWITCHING SPEED

ALL SOLID STATE



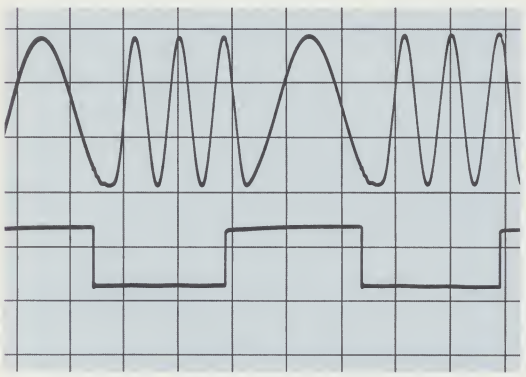
999.9 Kc to 333.3 Kc, 30 Kc switching rate, 5 μsec/cm

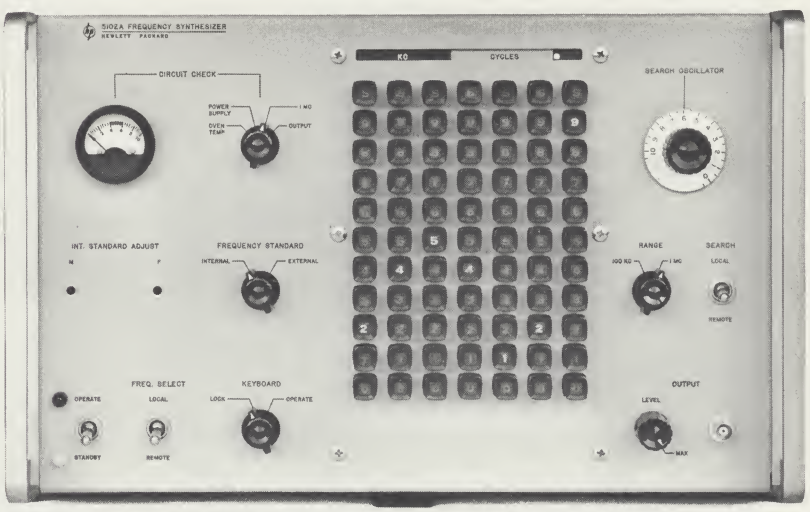
The HEWLETT-PACKARD MODEL 5102A FREQUENCY SYNTHESIZER provides any output frequency from 0.1 cps to 1 Mc, selectable in steps as small as 0.1 cps OR from 0.01 cps to 100 Kc in steps as small as 0.01 cps. The 100 Kc or 1 Mc maximum frequency output is selectable by a front panel RANGE switch. The output frequencies are digitally selected by front panel push-buttons, remote control, or a combination of the two. Each significant column may be continuously varied over its range by local or remote use of the SEARCH oscillator.

A level control is provided to allow adjusting the voltage output level between 300 mv and 1 volt RMS. The output frequency is derived from a precision single frequency source through direct synthesis, a technique which translates the long-term stability of the frequency source to the selected output. A precision quartz oscillator provided in the instrument or an external 1 Mc (or 5 Mc) frequency standard may be used as the frequency source.

HIGH SPEED SWITCHING

90 Kc to 30 Kc, 15 Kc switching rate, 10 μsec/cm





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DESIGN FEATURES

Solid state modular construction has been used throughout the 5102A. The modular concept enhances serviceability and enables the system to meet the stringent demands regarding spurious signals. Careful design and quality control insure that all modules are interchangeable from one instrument to another.

Particular care has been taken to insure an extremely clean output signal over the entire frequency range of the 5102A. This high order of spectral purity (and stability) is essential for accurate doppler measurements, spectroscopy, narrow band telemetry, or communication work and similar applications. The design and construction of the HEWLETT-PACKARD FREQUENCY SYNTHESIZER make it possible to obtain output signals with spurious content at least 70 db below the selected output, dc to 1 Mc, in the 1 MC RANGE position, and at least 90 db below the selected output, dc to 100 Kc, in the 100 KC RANGE position.

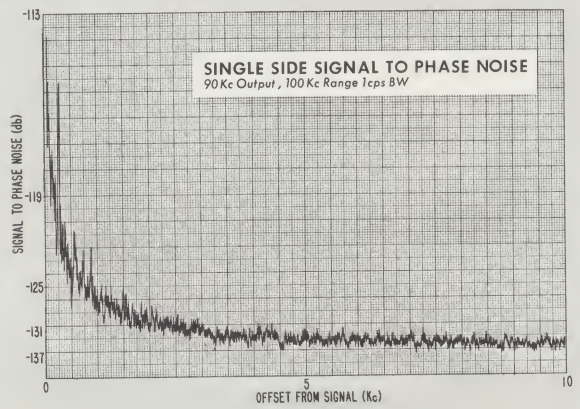
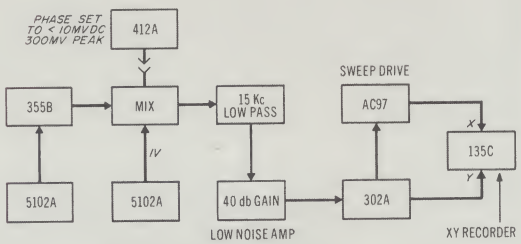


Figure 1.



MEASUREMENT SET-UP FOR NOISE PLOTS

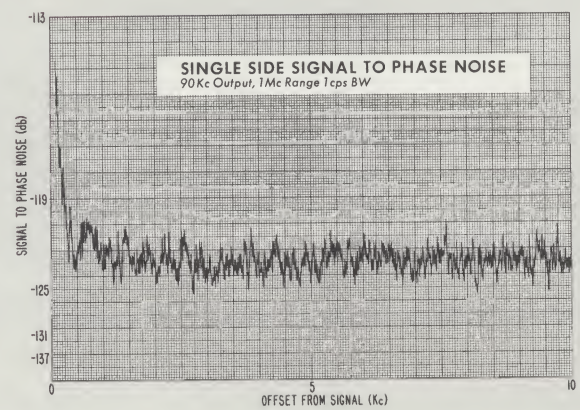


Figure 2.

The extremely good signal-to-phase noise characteristics of a typical 5102A synthesizer, in both the 100 KC RANGE position and the 1 MC RANGE position are shown in Figure 1 and Figure 2. Figure 3 shows a log plot of the single side phase noise.

These typical plots show the performance of the 5102A in applications requiring low noise; for example, local oscillator control in VLF Receiver/Transmitter work.

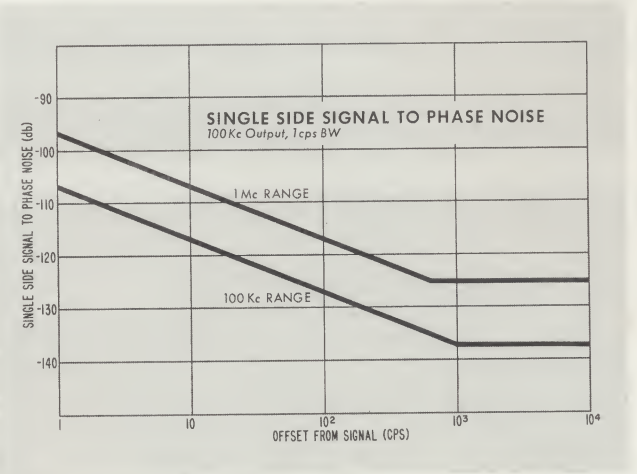


Figure 3.

OPERATIONAL FEATURES

Remote control is a standard feature on the 5102A. Any frequency or search oscillator position that can be selected by front panel push-buttons may also be remotely selected. Connectors located on the 5102A rear panel provide pins corresponding to each front panel push-button position, a ground connection, and a — 12.6 volt line for use in remote control. The — 12.6 voltage is available in two arrangements: continuous and switched (present when REMOTE mode is selected at front panel). This lends additional versatility since it enables the use of a combination of remote and local control. The combination of local and remote control can be used with the FREQUENCY SELECT switch in LOCAL. In this switch position, any column not selected locally by depressing a push-button in that column may be remotely controlled. Since no phase-locked loops are involved, switching from one output frequency to another can be accomplished very rapidly, either from the front panel push-buttons or remotely. Less than 20 μ seconds is required to change the output frequency. The two oscilloscope trace reproductions on the cover of this data sheet are typical results. For the 20 μs switching speed the controller must provide a low impedance connection to the — 12.6 volts for the "on" condition and + 1.5 volts for the "off" condition.

The search oscillator provides continuous tuning in any selected column plus an external sweep capability. This is an L-C oscillator which allows the operator to continuously "search" any significant column from 100 Kc to 0.01 cps either manually by a front panel control or remotely by application of a suitable voltage. The typical voltage vs. frequency characteristics is shown in Figure 4. The approximate slope is 10% of the selected column's range per volt.

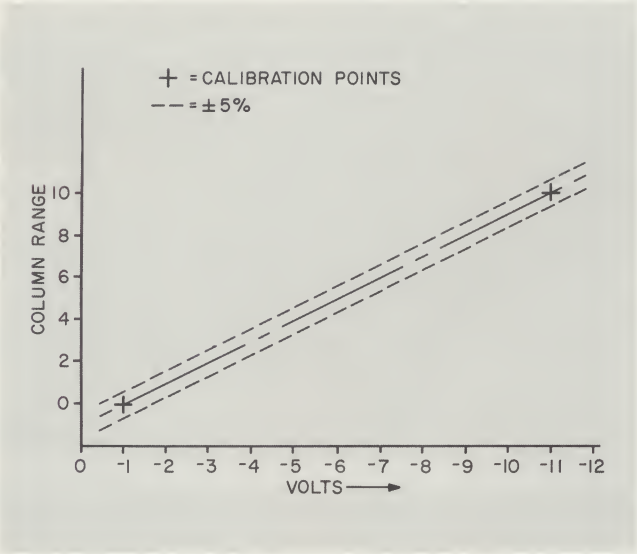


Figure 4.

If the search oscillator is used, the stability of the Synthesizer output is determined by either that of the standard instrument or that of the search oscillator—depending on the column which is "searched." The search oscillator has a root-mean-square deviation of approximately 1 cycle (one second average) if used in the most significant column that can be searched (100 Kc steps). This Δf_{rms} is reduced by a factor of 10 for each less-significant column that is searched. As an example, consider that the search oscillator is used in the 10 Kc column, at an output frequency of 1 Mc. The instability in the output frequency due to the search oscillator is then:

$$\frac{\Delta f_{rms}}{f_{out}} = \frac{0.1 \text{ cps}}{1 \times 10^6 \text{ cps}} = 1 \times 10^{-7}$$

At this output frequency, and using one second averaging, the short term stability of the Synthesizer itself is on the order of 1×10^{-10}. Consequently, the search oscillator governs in this case, but this is very stable for a sweep oscillator application.

The search oscillator may be frequency modulated from an external source at a maximum sine wave rate of 1 Kc while retaining the voltage control calibration.

SPECIFICATIONS

OUTPUT FREQUENCY: 100 KC RANGE—50 cps to 100 Kc. 1 MC RANGE—50 cps to 1 Mc.

►**OUTPUT LEVEL:** Maximum output of 1 volt RMS ± 1 db into a 50 ohm resistive load. A minimum of 10 db continuously variable attenuation provided by LEVEL control (front panel OUTPUT BNC).

AUXILIARY OUTPUTS:

LO LEVEL; 100 KC RANGE—DC to 100 Kc. 1 MC RANGE—DC to 1 Mc (f_o). (Output on rear panel.)

f_o + 30 MC; 30 to 31 Mc range simultaneously available at rear output BNC. (f_o is selected frequency, DC to 1 Mc, independent of RANGE setting.)

FREQUENCY STANDARD; 1 Mc buffered output available continuously at rear BNC.

LEVELS, AUXILIARY OUTPUTS:

LO LEVEL; 80 millivolts RMS minimum, open circuit. Source impedance 1000 ohms with approx. 70 pf shunt capacitance.

f_o + 30 MC; 1 volt RMS, ± 2 db into a 50 ohm resistive load.

FREQUENCY STANDARD; 1 volt RMS; ± 1.5 db into a 50 ohm resistive load.

FREQUENCY RESPONSE: Output flat within ± 0.5 db over the entire frequency range at any output level setting.

DIGITAL FREQUENCY SELECTION: 100 KC RANGE; 0.01 cps through 10 Kc per step. 1 MC RANGE; 0.1 cps through 100 Kc per step. (OUTPUT, LO LEVEL and f_o + 30 Mc.) Selection by front panel push-buttons or through appropriate rear panel connection.

SWITCHING TIME: < 20 μ seconds for any change in frequency.

SEARCH OSCILLATOR: A search oscillator provides continuously variable frequency selection in any desired column (by depressing the "S" button in that column) over the complete range of that column. Manual coverage by a front panel control or control by an externally applied voltage (— 1 to — 11 volts).

The SEARCH OSCILLATOR range may be externally swept up to a 1 Kc rate (with a sinewave input to a rear BNC) with retention of calibration. Linearity is ± 5% of full range in column selected. (See Figure 4.)

SIGNAL-TO-PHASE NOISE RATIO (OUTPUT):* 100 KC RANGE; > 74 db. 1 MC RANGE; > 64 db.

SIGNAL-TO-AM NOISE RATIO (OUTPUT):* 100 KC RANGE; > 80 db for frequencies above 30 Kc. 1 MC RANGE; > 74 db for frequencies above 100 Kc.

SIGNAL-TO-PHASE NOISE RATIO (f_o + 30 Mc):* > 60 db.

SIGNAL-TO-AM NOISE RATIO (f_o + 30 Mc):* > 80 db.

RMS FRACTIONAL FREQUENCY DEVIATION (OUTPUT):

100 KC RANGE		1 MC RANGE		
Ave. Time	100 Kc Output Frequency	Ave. Time	100 Kc Output Frequency	1 Mc Output Frequency
10 ms	3×10^{-8}	10 ms	1×10^{-7}	1×10^{-8}
1 sec	3×10^{-10}	1 sec	1×10^{-9}	1×10^{-10}

RMS FRACTIONAL FREQUENCY DEVIATION (f_o + 30 Mc):

Ave. Time	Output Frequency
10 msec	6×10^{-10}
1 sec	1×10^{-11}

SPURIOUS SIGNALS: 100 KC RANGE; > 90 db down. 1 MC RANGE; > 70 db down (non-harmonically related signals).

HARMONIC SIGNALS: > 35 db below the selected frequency (with proper termination).

* *In a 30 Kc band centered on the carrier, excluding a 1 cps band centered on the carrier.*

INTERNAL FREQUENCY STANDARD

TYPE: 1 Mc Quartz Oscillator.

AGING RATE: Less than $\pm$ 3 parts in 10^9 per 24 hours.

STABILITY: As a function of ambient temperature: $\pm$ 2 x 10^{-10} per °C from 0°C to + 55°C.
As a function of line voltage: $\pm$ 5 x 10^{-11} for a $\pm$ 10% change in line voltage (rated at 115 or 230 volts rms line voltage).

RMS FRACTIONAL FREQUENCY DEVIATION:

Ave. Time	1 Mc Output Frequency
10 millisec	6 x 10^{-10}
1 sec	1 x 10^{-11}

SIGNAL-TO-PHASE NOISE RATIO:* > 85 db

SIGNAL-TO-AM NOISE RATIO:* > 80 db

HARMONIC SIGNALS: > 40 db below the output (with proper termination).

PHASE LOCKING CAPABILITY: A voltage control feature allows 5 parts in 10^8 frequency control for — 5 to + 5 volts applied externally.

EXTERNAL FREQUENCY STANDARD

INPUT REQUIREMENTS: 1 Mc or 5 Mc, 0.2 v rms minimum, 5 v maximum across 500 ohms. Stability and spectral purity of 5102A FREQUENCY SYNTHESIZER will be partially determined by the characteristics of the external standard if used.

** In a 30 Kc band centered on the carrier, excluding a 1 cps band centered on the carrier.*

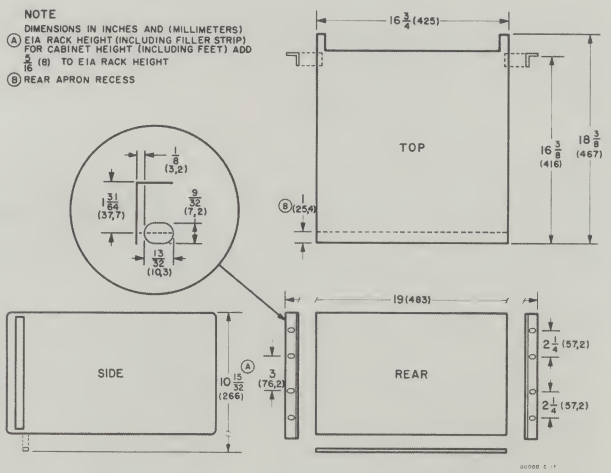
GENERAL

OPERATING TEMP. RANGE: 0 to + 55°C.

INTERFERENCE: Sample tested to MIL-I-6181D; MIL-I-26600, Class 1 and 3.

CONNECTORS: 2 ea. 50 pin Amphenol number 57-40500, REMOTE CONTROL 1 ea. BNC for the following: 1 Mc frequency standard output, rear; Phase locking control input, rear; 1 or 5 Mc frequency standard input, rear; Search Oscillator input, rear; f_o + 30 Mc output, rear; DC to maximum frequency output (LO LEVEL), rear; 50 cps to maximum frequency output, rear (through access hole covered by plug-button), or front.

DIMENSIONS:



WEIGHT: Net, 75 lbs. *(34 kg)*. Shipping, 127 lbs. *(58 kg)*.

►**POWER:** 115 or 230v $\pm$ 10%, 50 to 400 cps, 50 watts nominal.

►**PRICE:** $6,500.00.

Prices f.o.b. factory
Data subject to change without notice
► Indicates change from prior specifications

HEWLETT hp PACKARD

FREQUENCY SYNTHESIZER

model 5103A

TECHNICAL DATA 1 AUG 65

DUAL RANGE

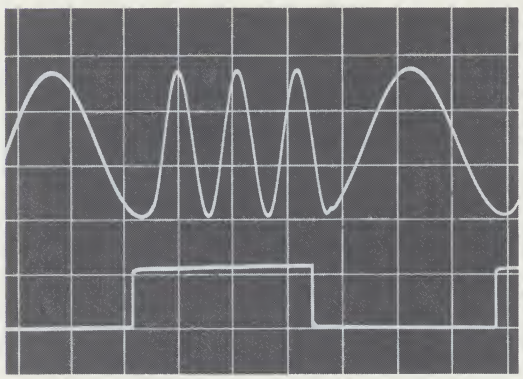
DC to 1 Mc, Spurious 70 DB Down
DC to 10 Mc, Spurious 50 DB Down

DIGITAL FREQUENCY SELECTION

SWEEP 0 TO 10 MC

20 MICROSEC SWITCHING SPEED

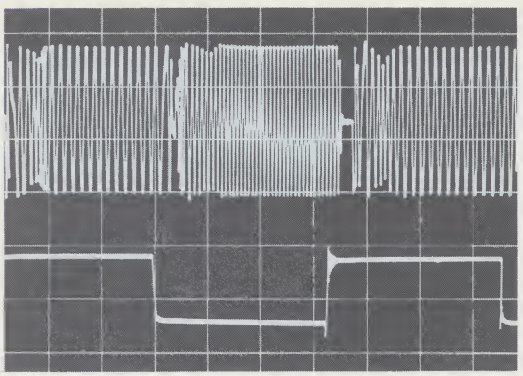
ALL SOLID STATE



20 Kc to 60 Kc, 10 Kc switching rate, 20 μsec/cm
10 MC RANGE

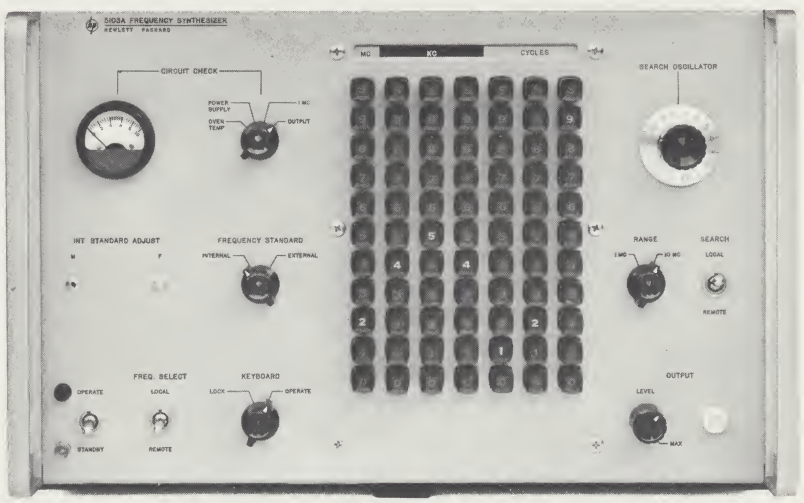
HIGH SPEED SWITCHING

1.2 Mc to 2.7 Mc, 30 Kc switching rate, 5 μsec/cm
10 MC RANGE



The HEWLETT-PACKARD MODEL 5103A FREQUENCY SYNTHESIZER provides any output frequency from 1 cps to 10 Mc, selectable in steps as small as 1 cps OR from 0.1 cps to 1 Mc in steps as small as 0.1 cps. The 1 Mc or 10 Mc maximum frequency output is selectable by a front panel RANGE switch. The output frequencies are digitally selected by front panel push-buttons, remote control or a combination of the two. Each significant column may be continuously varied over its range by local or remote use of the SEARCH oscillator.

A level control is provided to allow adjusting the voltage output level between 300 mv and 1 volt RMS. The output frequency is derived from a precision single frequency source through direct synthesis, a technique which translates the long-term stability of the frequency source to the selected output. A precision quartz oscillator provided in the instrument or an external 1 Mc (or 5 Mc) frequency standard may be used as the frequency source.



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DESIGN FEATURES

Solid state modular construction has been used throughout the 5103A. The modular concept enhances serviceability and enables the system to meet the stringent demands regarding spurious signals. Careful design and quality control insure that all modules are interchangeable from one instrument to another.

Particular care has been taken to insure an extremely clean output signal over the entire frequency range of the 5103A. This high order of spectral purity (and stability) is essential for accurate doppler measurements, spectroscopy, narrow band telemetry, or communication work and similar applications. The design and construction of the HEWLETT-PACKARD FREQUENCY SYNTHESIZER make it possible to obtain output signals with spurious content at least 70 db below the selected output, dc to 1 Mc, in the 1 MC RANGE position and at least 50 db below the selected output, dc to 10 Mc in the 10 MC RANGE position.

The extremely good signal-to-phase noise characteristics of a typical 5103A synthesizer, in both the 1 MC RANGE position and the 10 MC RANGE position are shown in Figure 1 and Figure 2. Figure 3 shows a log plot of the single-side phase noise.

These typical plots show the performance of the 5103A in applications requiring low noise; for example, local oscillator control in VLF Receiver/Transmitter work.

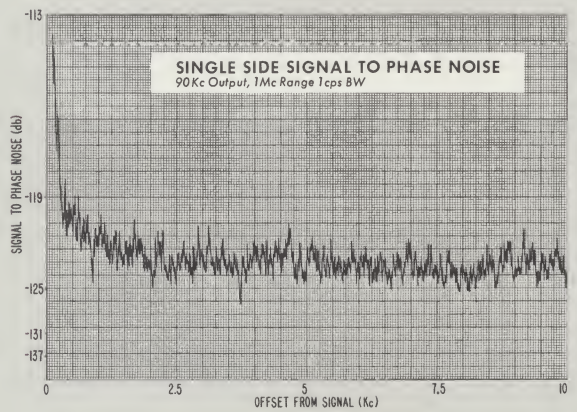
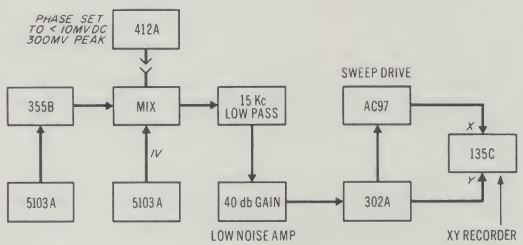


Figure 1.



MEASUREMENT SET-UP FOR NOISE PLOTS

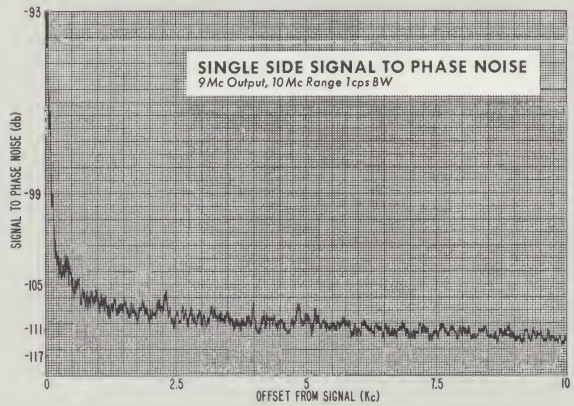


Figure 2.

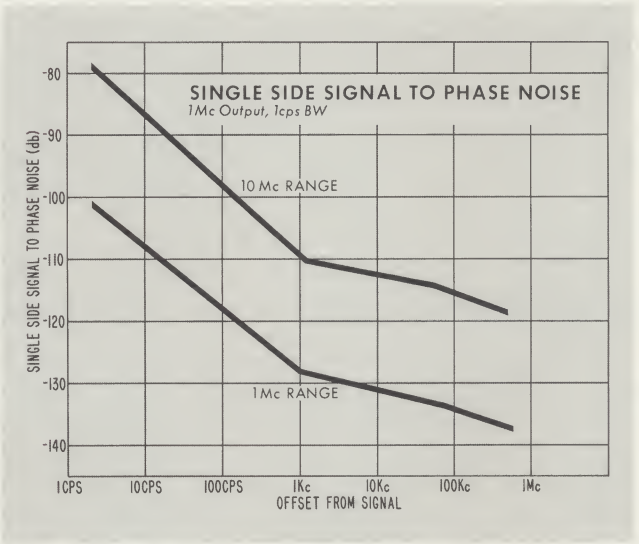


Figure 3.

OPERATIONAL FEATURES

Remote control is a standard feature on the 5103A. Any frequency or search oscillator position that can be selected by front panel push-buttons may also be remotely selected. Connectors located on the 5103A rear panel provide pins corresponding to each front panel push-button position, a ground connection, and a — 12.6 volt line for use in remote control. The — 12.6 voltage is available in two arrangements: continuous and switched (present when REMOTE mode is selected at front panel). This lends additional versatility since it enables the use of a combination of remote and local control. The combination of local and remote control can be used with the FREQUENCY SELECT switch in LOCAL. In this switch position, any column not selected locally by depressing a push-button in that column may be remotely controlled. Since no phase-locked loops are involved, switching from one output frequency to another can be accomplished very rapidly, either from the front panel push-buttons or remotely. Less than 20 μ seconds is required to change the output frequency. The two oscilloscope trace reproductions on the cover of this data sheet are typical results. For the 20 μs switching speed the controller must provide a low impedance connection to the — 12.6 volts for the "on" condition and + 1.5 volts for the "off" condition.

The search oscillator provides continuous tuning in any selected column plus an external sweep capability. This is an L-C oscillator which allows the operator to continuously "search" any significant column from 1 Mc to 0.1 cps either manually by a front panel control or remotely by application of a suitable voltage. The typical voltage vs. frequency characteristic is shown in Figure 4. The approximate slope is 10% of the selected column's range per volt.

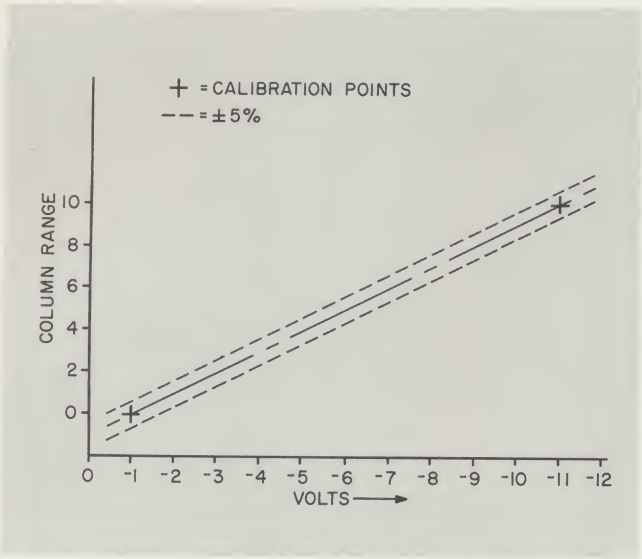


Figure 4.

If the search oscillator is used the stability of the Synthesizer output is determined by either that of the standard instrument or that of the search oscillator—depending on the column which is "searched." The search oscillator has a root-mean-square deviation of approximately 1 cycle (one second average) if used in the most significant column that can be searched (1 Mc steps). This Δf_{rms} is reduced by a factor of 10 for each less significant column that is searched. As an example, consider that the search oscillator is used in the 10 Kc column, at an output frequency of 1 Mc. The instability in the output frequency due to the search oscillator is then:

$$\frac{\Delta f_{rms}}{f_{out}} = \frac{0.1 \text{ cps}}{1 \times 10^6 \text{ cps}} = 1 \times 10^{-7}$$

At this output frequency, and using one second averaging, the short term stability of the Synthesizer itself is on the order of 1×10^{-10}. Consequently, the search oscillator governs in this case, but this is very stable for a sweep oscillator application.

The search oscillator may be frequency modulated from an external source at a maximum sine wave rate of 1 Kc while retaining the voltage control calibration.

SPECIFICATIONS

OUTPUT FREQUENCY: 1 MC RANGE—50 cps to 1 Mc. 10 MC RANGE—50 cps to 10 Mc.

►**OUTPUT LEVEL:** Maximum output of 1 volt RMS ± 1 db into a 50 ohm resistive load. A minimum of 10 db continuously variable attenuation provided by LEVEL control (front panel OUTPUT BNC).

AUXILIARY OUTPUTS:

LO LEVEL; 1 MC RANGE—DC to 1 Mc (f_o). 10 MC RANGE—DC to 10 Mc. (Output on rear panel.)

f_o + 30 MC; 30 to 31 Mc range simultaneously available at rear output BNC. (f_o is selected frequency, DC to 1 Mc, independent of RANGE setting.)

FREQUENCY STANDARD; 1 Mc buffered output available continuously at rear BNC.

LEVELS, AUXILIARY OUTPUTS:

LO LEVEL, 20 millivolts RMS minimum, open circuit. Source impedance 10,000 ohms with approx. 70 pf shunt capacitance.

f_o + 30 MC; 1 volt RMS, ± 2 db into a 50 ohm resistive load.

FREQUENCY STANDARD; 1 volt RMS, ± 1.5 db into a 50 ohm resistive load.

FREQUENCY RESPONSE: Output flat within ± 0.5 db over the entire frequency range at any output level setting on 1 MC RANGE. Flat within ± 1 db over the entire frequency range at any output level setting on 10 MC RANGE.

DIGITAL FREQUENCY SELECTION: 1 MC RANGE; 0.1 cps through 100 Kc per step. 10 MC RANGE; 1 cps through 1 Mc per step. (OUTPUT, LO LEVEL and f_o + 30 Mc.) Selection by front panel pushbuttons or through appropriate rear panel connection.

SWITCHING TIME: < 20 μ seconds for any change in frequency.

SEARCH OSCILLATOR: A search oscillator provides continuously variable frequency selection in any desired column (by depressing the "S" button in that column) over the complete range of that column. Manual coverage by a front panel control or control by an externally applied voltage (— 1 to — 11 volts). The SEARCH OSCILLATOR range may be externally swept up to a 1 Kc rate (with a sinewave input to a rear BNC) with retention of calibration. Linearity is ± 5% of full range in column selected. (See Figure 4.)

SIGNAL-TO-PHASE NOISE RATIO (OUTPUT):* 1 MC RANGE; > 64 db. 10 MC RANGE; > 54 db.

►**SIGNAL-TO-AM NOISE RATIO (OUTPUT):*** 1 MC RANGE; > 74 db for frequencies above 100 Kc. 10 MC RANGE; > 74 db for frequencies above 500 Kc.

SIGNAL-TO-PHASE NOISE RATIO (f_o + 30 Mc):* > 60 db.

SIGNAL-TO-AM NOISE RATIO (f_o + 30 Mc):* > 80 db.

RMS FRACTIONAL FREQUENCY DEVIATION (OUTPUT):

1 MC RANGE		10 MC RANGE	
Ave. Time	1 Mc Output Frequency	Ave. Time	10 Mc Output Frequency
10 ms	1×10^{-8}	10 ms	3×10^{-9}
1 sec	1×10^{-10}	1 sec	3×10^{-11}

RMS FRACTIONAL FREQUENCY DEVIATION (f_o + 30 Mc):

Ave. Time	Output Frequency
10 ms	6×10^{-10}
1 sec	1×10^{-11}

SPURIOUS SIGNALS: 1 MC RANGE; > 70 db. 10 MC RANGE; > 50 db. Below selected output, for non-harmonically related signals.

HARMONIC SIGNALS: 1 MC RANGE; > 35 db. 10 MC RANGE; > 35 db. Below selected output, with proper termination.

** In a 30 Kc band centered on the carrier, excluding a 1 cps band centered on the carrier.*

INTERNAL FREQUENCY STANDARD

TYPE: 1 Mc Quartz Oscillator.

AGING RATE: Less than $\pm$ 3 parts in 10^9 per 24 hours.

STABILITY: As a function of ambient temperature: $\pm$ 2 x 10^{-10} per °C from 0°C to + 55°C.
As a function of line voltage: $\pm$ 5 x 10^{-11} for a $\pm$ 10% change in line voltage (rated at 115 or 230 volts rms line voltage).

RMS FRACTIONAL FREQUENCY DEVIATION:

Ave. Time	1 Mc Output Frequency
10 millisec	6 x 10^{-10}
1 sec	1 x 10^{-11}

SIGNAL-TO-PHASE NOISE RATIO:* > 85 db.

SIGNAL-TO-AM NOISE RATIO:* > 80 db.

HARMONIC SIGNALS: > 40 db below the output (with proper termination).

PHASE LOCKING CAPABILITY: A voltage control feature allows 5 parts in 10^8 frequency control for — 5 to + 5 volts applied externally.

EXTERNAL FREQUENCY STANDARD

INPUT REQUIREMENTS: 1 Mc or 5 Mc, 0.2v rms minimum, 5v maximum across 500 ohms. Stability and spectral purity of 5103A FREQUENCY SYNTHESIZER will be partially determined by the characteristics of the external standard if used.

** In a 30 Kc band centered on the carrier, excluding a 1 cps band centered on the carrier.*

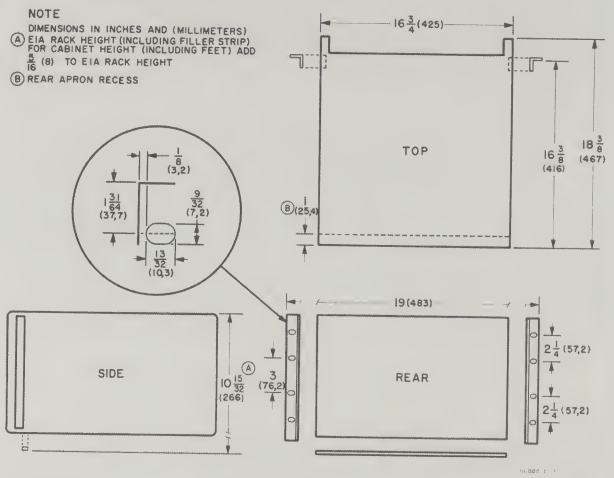
GENERAL

OPERATING TEMP. RANGE: 0 to + 55°C.

INTERFERENCE: Sample tested to MIL-I-6181D; MIL-I-26600, class 1 and 3.

CONNECTORS: 2 ea. 50 pin Amphenol number 57-40500, REMOTE CONTROL. 1 ea. BNC for the following: 1 Mc frequency standard output, rear; Phase locking control input, rear; 1 or 5 Mc frequency standard input, rear; Search Oscillator input, rear; f_o + 30 Mc output, rear; DC to maximum frequency output (LO LEVEL), rear; 50 cps to maximum frequency output, rear (through access hole covered by plug-button), or front.

DIMENSIONS:



WEIGHT: Net, 75 lbs. *(34 kg)*. Shipping, 127 lbs. *(58 kg)*.

►**POWER:** 115 or 230v $\pm$ 10%, 50 to 400 cps, 50 watts nominal.

►**PRICE:** $7,100.00.

Prices f.o.b. factory
Data subject to change without notice
► Indicates change from prior specifications